

# ULTRA-THIN SEMICONDUCTOR PACKAGE DEVICE AND METHOD FOR MANUFACTURING THE SAME

## 5 BACKGROUND OF THE INVENTION

### 1. Field of the Invention

This invention relates to semiconductor chip packaging technology, and more particularly to an ultra-thin semiconductor package and a method for manufacturing the same. This invention also relates to an electronic apparatus including an ultra-thin  
10 semiconductor package device.

### 2. Description of Related Art

In general, integrated circuit (IC) semiconductor chips such as memory chips are assembled in a package form and mounted on a circuit board of one of various electronic apparatuses. An interfacing structure is required to provide the electrical and physical interconnection between the IC chips and the circuit board. Lead frames are presently the most widely used interfacing structure in the semiconductor industry.

Fig. 1 is a cross-sectional view of a conventional IC device in which semiconductor chips are mounted on both sides of a lead frame in order to improve a mounting density of the package. This package structure is disclosed, for instance, in Japanese Unexamined Patent  
20 Publication No. 62-147360.

Referring to Fig. 1, a conventional semiconductor package 10 includes a die pad 13 and a lead frame having a plurality of leads 14. A semiconductor IC chip 11 is bonded to the die pad 13 by an adhesive 12. The semiconductor IC chip 11 is electrically interconnected to  
25 the leads 14 via bonding wires 16. The semiconductor IC chip 11 and bonding wires 16 are protected by a package body 17 made of an epoxy molding compound. Outer portions of the leads 14, which protrude from the package body 17, are bent in a form suitable for mounting the package onto a circuit board (not shown).

In the conventional semiconductor package 10, there is an increasing demand for  
30 thinner packages as smaller and lighter electronic apparatuses that employ package devices are developed. In particular, when two or more semiconductor chips 11 are stacked together in a single package body to increase memory capacity, a thinner package becomes even more important.

10 In order to make the semiconductor package thinner, reduction of the thickness of the semiconductor chip itself and reduction of the thickness of the lead frame have been considered. For instance, by applying a so-called wafer back lapping to a wafer, semiconductor chips can be made as thin as between 100 to 150  $\mu\text{m}$ . Using chips having this  
5 range of thickness, the overall thickness of the package device can be reduced to less than 1 mm.

Unfortunately, however, since the wafer is made of low-hardness material such as silicon, reducing the thickness of the semiconductor chip makes handling of the wafer more difficult and increases the possibility of chip cracks or wafer warpage. As a result, there are  
10 inevitable limitations on decreasing the thickness of the semiconductor chip; especially considering that the demand for improving yield of semiconductor products has resulted in an increase in the diameter of wafers to about 12 inches.

Reducing the thickness of the lead frame also has disadvantages. For example, if the thickness of a lead frame is too small, the lead frame is very fragile, leading to a decrease in the productivity of the assembly process. Based on the need for handling lead frames and for  
15 forming outer leads, 100  $\mu\text{m}$  is a known limit on the thinness of the lead frame.

Conventional instruments and plastic packaging machinery are widely used for packaging semiconductor devices. Unfortunately, however, when new assembly technologies such as CSP (Chip Scale or Size Package) technology are used to make the  
20 package device thinner, costs for replacing existing instruments and machinery are incurred.

### SUMMARY OF THE INVENTION

An object of this invention is to provide an ultra-thin semiconductor package having a thickness preferably less than 1.0 mm, and more preferably less than 0.7 mm or 0.5 mm,  
25 while still improving the mounting density of the package device.

Another object of this invention is to provide a method of manufacturing an ultra-thin semiconductor package.

Another purpose of this invention is to produce an ultra-thin semiconductor package capable of using existing instruments for manufacturing a conventional plastic package to  
30 manufacture the ultra-thin semiconductor package of this invention.

Another object of this invention is to provide an ultra-thin semiconductor package having improved reliability through an easy to manage process.

According to the present invention, an ultra-thin semiconductor package includes a lead frame having a die pad and a plurality of leads surrounding the die pad. The die pad

includes a chip attaching part to which the semiconductor chip is attached and a peripheral part, integral with and surrounding the chip attaching part. A first thickness of the chip attaching part is smaller than a second thickness of the leads. The package device also has a semiconductor IC chip, bonding wires electrically connecting the chip and each of the leads, and a package body for encapsulating the semiconductor chip, bonding wires, die pad and inner portions of the leads.

One of the advantages of the present invention lies in that the thickness of the die pad is smaller than the thickness of the leads. The die pad thickness is preferably equal to or less than 50%, and more preferably ranging between 30-50%, of the thickness of the leads. The overall thickness of the package device is preferably equal to or less than 0.7 mm.

According to one aspect of the present invention, an ultra-thin package device may comprise two semiconductor chips, wherein one chip is attached to each side of the die pad. At least two tie bars are connected to a die pad peripheral part. The tie bars have a third thickness which is equal to either the first thickness of the chip attaching part or the second thickness of the leads. The peripheral part may have the same thickness as either the chip attaching part or the leads. When the thickness of the peripheral part is made greater than that of the chip attaching part and identical to the lead thickness, the die pad has an approximately U-shaped cross-section.

When the direction of protrusion of the peripheral part faces downwards in a direction of the thickness of the package body, it is preferable to bend-down the tie bar so that the die pad is located centrally in the package body. Further, if the peripheral part protrudes upward in the package body, it is preferable to dispose the leads in an upper portion of the package body to obtain a balanced structure.

According to another aspect of the present invention, the die pad may be divided into first and second die pads each having its own tie bar, chip attaching part, and peripheral part. In this embodiment, the tie bar, chip attaching part, and the peripheral part all have the same thickness but are thinner than the leads.

According to another aspect of the present invention, a method of manufacturing an ultra-thin package device includes preparing a lead frame including a die pad, a tie bar, and a plurality of leads. The die pad is provided with a chip attaching part and a peripheral part surrounding the chip attaching part. The chip attaching part is etched to make it thinner. The amount of etching of the chip attaching part can be determined by a pressure and applying time of an etchant. The semiconductor chip is die bonded to the chip attaching part of the die pad. The semiconductor chip and leads are electrically interconnected through wire bonding.

A package body is then formed by encapsulating the semiconductor chip, bonding wires, and inner portions of the leads. The package body is preferably formed at a low-temperature (i.e., under about 170-175°C).

According to still another aspect of the present invention, a method of manufacturing an ultra-thin package device includes preparing a wafer having an active surface on which a plurality of semiconductor chips are formed. An adhesive layer is attached to the backside of the chip. A UV tape is attached to the adhesive layer. UV light irradiates the UV tape to remove the adhesiveness between the adhesive layer and the UV tape. The wafer is cut into a plurality of semiconductor chips. The cut chips are then completely separated from the wafer state UV tape. The adhesive layer remains attached to the backside of the individual chips.

Die bonding is accomplished through a series of steps. A semiconductor chip is attached to the top surface of the chip attaching part. A semiconductor chip is also attached to the bottom surface of the chip attaching part. The adhesive layer, which was attached to the backside of the chip in the wafer state, is used in die bonding.

Wire bonding proceeds by wire bonding the chip attached to the top surface of the chip attaching part and wire bonding the chip attached to the bottom surface of the chip attaching part. The wire bonding preferably uses a reverse wire bonding process in which balls are formed on the leads and stitches are formed on the chip electrode pads. It is further preferable that the length of bonding wire connected to the chip mounted on the top surface of the chip attaching part is different from the length of bonding wire connected to the chip mounted on the bottom surface of the chip attaching part. Specifically, it is desirable for a bonding wire connected to a chip having shorter a vertical distance to the leads to have a smaller length.

Applying the ultra-thin technology of this invention, it is possible to provide a stack package device having a thickness of 0.6 mm or less and a single chip package device having a thickness of 0.48 mm or less. These package devices can be widely used in various portable electronic apparatuses (such as memory cards, for example) that require packages with minimal vertical heights.

According to the present invention, it is possible to improve the physical reliability of an ultra-thin package device and to easily manage the assembly processes. Specifically, since the ultra-thin package device is obtained by making the die pad thinner, the reliability of the assembly process and the resultant package device is not affected. Furthermore, according to the preferred embodiments of this invention, there is no need to invest in additional

equipment to manufacture the ultra-thin package device, since conventional machinery and instruments can be used to reduce the die pad thickness.

In addition, according to the package structure of the present invention, imperfect molding can be prevented by adjusting the vertical position of the die pad or forming an unbalanced package body. Moreover, since only the thickness of the chip attaching is reduced, while the other parts, including a peripheral part and a tie bar are not affected, the die pad supporting function of the tie bar is retained and the physical strength and reliability of the package device is maintained.

Further, when a die pad divided into at least two parts is employed, the area occupied by the die pad can be reduced. Degradation of reliability due to the mismatch of thermal coefficients of expansion among materials of the die pad and other elements can thereby be prevented.

The ultra-thin package device of the present invention is not limited by the type or number of semiconductor chips included in the package, nor by the type of adhesive used to attach the chip to the die pad. It is also possible to reduce the wire loop height of a package by adopting a reverse wire bonding approach.

#### BRIEF DESCRIPTION OF THE INVENTION

The foregoing and other objects, features, and advantages, will be more clearly understood from the following detailed description of preferred embodiments taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a cross-sectional view of a conventional semiconductor package device employing a lead frame.

Fig. 2 is a plan view of an ultra-thin semiconductor package according to a first embodiment of the present invention.

Fig. 3a is a cross-sectional view of the semiconductor package of Fig. 2 taken along a line III-III, and Fig. 3b is a partial detail view of the package of Fig. 3a.

Fig. 4 is a cross-sectional view of the semiconductor package of Fig. 2 taken along a line IV-IV.

Fig. 5 is a cross-sectional view of an ultra-thin semiconductor package according to a second embodiment of the present invention.

Fig. 6 is a cross-sectional view of an ultra-thin semiconductor package according to a third embodiment of the present invention.

Figs. 7a and 7b are cross-sectional views of an ultra-thin semiconductor package according to a fourth embodiment of the present invention.

Fig. 8 is a cross-sectional view of an ultra-thin semiconductor package according to a fifth embodiment of the present invention.

Fig. 9 is a partially detailed view illustrating a reverse wire bonding structure in an ultra-thin semiconductor package according to another aspect of the present invention.

Fig. 10 is a cross-sectional view of an ultra-thin semiconductor package according to a sixth embodiment of the present invention.

Figs. 11a and 11b are, respectively, a plan view and a cross-sectional view of an ultra-thin semiconductor package according to a seventh embodiment of the present invention.

Figs. 12a to 12f are cross sectional views of a lead frame illustrating a process for making a die pad of a lead frame partially thinner according to yet another aspect of the present invention.

Figs. 13a to 13i are partial cross-sectional views illustrating a method of manufacturing an ultra-thin semiconductor package according to still another aspect of the present invention.

Figs. 14a and 14b are, respectively, a plan view and a cross-sectional view of a memory card having an ultra-thin semiconductor package according to an embodiment of the present invention.

Fig. 15 is a cross-sectional view of a package device formed according to thin-packaging technology of the present invention.

Fig. 16 is a cross-sectional view of another package device formed according to thin-packaging technology of the present invention.

## DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Ultra-thin semiconductor package configurations according to various aspects and embodiments of the present invention will now be described with reference to Figs. 2 through 11.

### First Embodiment

Fig. 2 is a partial plan view of an ultra-thin semiconductor package according to a first embodiment of the present invention. Fig. 3a is a cross-sectional view of the ultra-thin semiconductor package of Fig. 2, taken along line III-III. Fig. 3b is a partial detail view of

the ultra-thin semiconductor package of Fig. 3a. Fig. 4 is a cross-sectional view of the ultra-thin semiconductor package of Fig. 2, taken along line IV-IV.

Referring to Figs. 2 through 4, an ultra-thin semiconductor package 100 employs a lead frame 110 comprising a die pad 112, tie bars 114, and leads 116. The die pad 112 is located centrally in the package 100. A plurality of leads 116 and tie bars 114 are disposed around the die pad 112. The leads 116 are separated from the die pad 112, but are indirectly connected to the die pad 112 through the tie bars 114. The die pad 112 includes a chip attaching part 112a to which a semiconductor chip 120 is bonded, and a peripheral part 112b integrally formed with and surrounding the chip attaching part 112a.

Upper and lower semiconductor chips 120a, 120b are bonded to respective sides of the die pad 112. More specifically, an upper chip 120a is attached to an upper surface of the die pad chip attaching part 112a, while a lower chip 120b is attached to a lower surface thereof. The semiconductor chips 120 may, for example, be DRAMs, flash memories, or non-memory IC devices. The upper and lower chips may have the same functionality or they may be different chip-types, as desired. In order to increase the memory capacity of the package device, for example, the same memory chips may be employed on both the upper and lower surface of the chip attaching part 112a.

The upper and lower chips 120a, 120b are attached to the chip attaching part 112a of the die pad 112 via an adhesive layer 122. The adhesive layer 122 can be an epoxy such as an Ag-epoxy or an adhesive tape, such as a film type adhesive tape. The adhesive layer 122 is preferably a film type adhesive tape of epoxy resin, attached to the back of the chip in a wafer state. The semiconductor chip 120 is electrically interconnected to the leads 116 via bonding wires 124, which can be conventional gold wires.

The semiconductor IC chips 120, die pad 112, and bonding wires 124 are all encapsulated within the package body 126. The package body 126 is formed using an epoxy molding compound. During the manufacturing process for the package 100, the tie bar 114, which supports the die pad 112, is connected to the peripheral part 112b of the die pad 112 and remains within the package body 126. The leads 116, however, which provide an electrical and physical interface between the semiconductor package 100 and an external circuit board (not shown), have two portions. The first portion of the leads is the inner leads 116a, which are electrically interconnected to the semiconductor chips 120 via the bonding wires 124. The inner leads 116a remain within the package body 126. The second portion is the outer leads 116b, which are connected to the external circuit board. The outer leads 116b are located outside of the package body 126. The outer leads 116b are preferably bent and

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formed into a suitable shape, such as a Gull-wing shape, for mounting the package device 100 to the circuit board.

One of the advantages of various embodiments of the present invention lies in the fact that the thickness  $t_1$  of the chip attaching part 112a of the die pad 112 is smaller than the thickness  $t_2$  of the leads 116. The lead frame 110 used in the production of the package device 100 is conventionally made of copper or iron-nickel alloy (e.g., alloy42). As explained below, the lead frame 110 is prepared from a thin metal plate, and the die pad 112, tie bar 114, and leads 116 are formed by etching or stamping the metal plate. Additional elements, including a dam bar and a side rail, are also formed by etching or stamping. These elements are not shown in the drawings, however, since they are not included in the final package device 100.

The lead frame 110 can have various thicknesses depending on the type of the package device 100. The lead frame thickness is being increasingly reduced according to the miniaturization trend in package devices. For example, lead frames traditionally having a thickness of 300  $\mu\text{m}$  (12 mil), 250  $\mu\text{m}$  (10 mil), 200  $\mu\text{m}$  (8 mil), and 150  $\mu\text{m}$  (6 mil) are currently being replaced with 100  $\mu\text{m}$  (4 mil) lead frames. According to various aspects and embodiments of the present invention, even when a lead frame 110 having a thickness of about 100  $\mu\text{m}$  is employed, the thickness of the die pad 112 (and particularly the chip attaching part 112a) can be made ultra-thin. For example, the thickness of the chip attaching part 112a can be reduced to between about 30-50% of the lead frame thickness. The thickness of leads 116 ( $t_2$ ) can be about 100  $\mu\text{m}$ , while the thickness of the die pad 112 ( $t_1$ ) is about 40  $\mu\text{m}$ . The tie bar 114 can have the same thickness as the die pad 112 (e.g., 40  $\mu\text{m}$ ). In this embodiment, the chip attaching part 112a of the die pad 112 has a substantially identical thickness with the peripheral part 112b.

By making the die pad 112 thinner, it is possible to reduce the overall thickness of the package device 100. In this embodiment, the thickness ( $T$ ) of the package device 100 is about 0.58 mm. Referring specifically to Fig. 3b, the thickness of each of the adhesive layers 122 is between about 10-20  $\mu\text{m}$ , the thickness ( $t_3$ ) of the semiconductor IC chip 120 is between about 100-150  $\mu\text{m}$ , and the height (or loop height) ( $t_4$ ) of the bonding wires 124 from the upper surface of the chip 120 is about 80  $\mu\text{m}$ .

The loop height of the bonding wire 124 affects the overall thickness of the package device. It is therefore preferable to use a reverse bonding method to connect the wires between the chip 120 and the leads 116. Reverse bonding is so named because it is performed in a manner opposite to the conventional wire bonding method. In the



conventional method, wires are ball bonded to the chip electrode pads 128 and stitch bonded to the leads 116. In the reverse bonding method, the ball bonding is made on the leads 116 and the wires 124 are stitch bonded onto the chip electrode pads 128. In this manner, the wire height can be greatly reduced. For example, compared to the conventional value of about 150  $\mu\text{m}$ , the wire height from reverse bonding is about half (80  $\mu\text{m}$ ). Metal bumps may be formed on the chip electrode pads 128 to alleviate the impact on the chip 120 during the wire bonding process.

The die pad 122 is made thinner by partially removing an upper side, lower side, or both, of the die pad 112 during the manufacturing process of the lead frame 110. This means that the die pad 112 is removed by a constant amount on one or both sides. As explained previously, the die pad 112 is supported by the tie bar 114 during the production process of the lead frame. Accordingly, even when a thinner die pad 112 is employed, the physical strength of the lead frame 110 is not significantly affected. Furthermore, existing equipment and processes for the production of the lead frame 110 can be used to produce the thinner die pad structure of the various embodiments of this invention.

### The Second and Third Embodiments

In the preceding embodiment, the die pad 112 is partially removed on both sides. In the second and third embodiments, described below, only one side of the die pad 112 is partially removed. If the die pad 112 is partially removed on one side, the die pad 112 will not align with both the top and bottom surfaces of the leads 116. In other words, the die pad 112 will appear to be shifted away from a center of package body 126 in either an upward or downward direction. This causes an imbalanced package body 126 in relation to the active surface (the surface where the chip electrode pads are formed) of each of the upper and lower semiconductor chips 120a and 120b. This may result in incomplete molding of the package body 126.

Accordingly, when the die pad is partially removed on one side to make the die pad thinner, a procedure is necessary to attain a balanced die pad placement. The second and third embodiments address this problem. The second embodiment obtains a balanced structure by vertically adjusting the die pad location. The third embodiment of the present invention achieves balance by forming an asymmetrical package body structure. These embodiments will now be explained in further detail with reference to Figs. 5 and 6, respectively.

Referring to Fig. 5, in the second embodiment of the present invention, a die pad 212 is disposed a predetermined distance 'd' below a tie bar 214. In other words, the die pad 212 is down-set from the horizontal top surface of the lead frame 210. Accordingly, even when one side of the die pad 212 is partially removed, the die pad 212 can be centered vertically in the package body 126. Therefore, a distance 'd1' from the active surface of the upper semiconductor chip 120a to the top surface of the package body 126 is equal to a distance 'd2' measured from the active surface of the lower semiconductor chip 120b to the bottom surface of the package body 126. The proper amount of down-set 'd' depends on the thickness of the chips, leads, die pad and package body and can be varied depending on whether the upper and lower semiconductor chips have the same or different thicknesses.

In the third embodiment of the present invention, described with reference to Fig. 6, the package body 126 is formed differently depending on the location of the die pad 312. In the conventional structure, the package body is formed having the same upper and lower thicknesses with respect to the lead. In the third embodiment of this invention, upper and lower parts of the package body 126 have the same thickness with reference to the die pad 312. The thickness 't5' of the upper part of the package body 126 with respect to the leads 316, however, is different than the thickness 't6' of the lower part of package body 126 with reference to the leads 316. In this way, the die pad 312 is located at the vertical center of the package body 126. Accordingly, when viewed in reference to the leads 316 of the lead frame 310, an unbalanced molding is formed. This unbalanced body structure can be obtained by forming cavities of upper and lower molds having different sizes.

#### The Fourth Embodiment

A fourth embodiment of the present invention will now be described with reference to Figs. 7a and 7b, which provide cross-sectional views of the ultra-thin package device according to this embodiment.

A tie bar has the same thickness as the die pad peripheral part. The peripheral part of the die pad may have the same thickness as either the die pad chip attaching part or the leads. Whether the thickness of the peripheral part matches the chip attaching part or the leads is determined by whether the peripheral part and tie bar is partially removed along with the die pad chip attaching part.

In the first embodiment, the peripheral part 112b, the tie bar 114, and the chip attaching part 112a all share the same thickness. In this embodiment, however, the peripheral part 412b and tie bar 414 have the same thickness as the leads 116.

Referring to Figs. 7a and 7b, a die pad 412 comprises a chip attaching part 412a, to which semiconductor chips 120 are attached, and a peripheral part 412b, which is connected to a tie bar 414. The chip attaching part 412a is made thinner by partially removing the die pad on the chip attaching part. The peripheral part 412b and the tie bar 414 are not removed. Accordingly, apart from the chip attaching part 412a, all of the remaining parts of the lead frame 410, including the peripheral part 412b, tie bar 414, and leads 416, have the same thickness. The chip attaching part 412a of the die pad 412 therefore provides the primary contribution to the thinning of the package 400. Further, although the die pad is thinner, because the thickness of the tie bar 414 and the peripheral part of the die pad 412 remain unchanged, the supporting ability is unaffected.

#### The Fifth Embodiment

Figs. 8 to 10 show a stack package device having a die pad thickness made different from a lead thickness by partially removing one side of the die pad, according to a fifth embodiment of the present invention. Referring to Fig. 8, a stack package device 500 includes upper and lower semiconductor chips 120a and 120b attached, via an adhesive 122, to respective upper and lower sides of a die pad chip attaching part 512a. A peripheral part 512b of the die pad 512 is thicker than the chip attaching part 512a but has the same thickness as the inner leads 516a. The thickness of the chip attaching part 512a is preferably about 30-50% of the thickness of the peripheral part 512b. As a result, the die pad 512 has a cross-section having an approximate "U" shape, in which the protruding portions 512b at the ends point upward.

In the package body forming process, a vertically balanced structure with respect to the die pad is desirable. To accomplish this during the injection molding process, the upper thickness 'D1' and the lower thickness 'D2' of the package body 526 are made different with reference to the inner leads 516a to maintain an equal distance 'd' from the top and bottom surfaces of the package body 526 to upper and lower semiconductor chips 120a and 120b, respectively. For example, assuming the thickness of the package body 526 is 580  $\mu\text{m}$ , the thickness of the upper and lower chips 120a, 120b is 120  $\mu\text{m}$ , the thickness of the adhesive is 20  $\mu\text{m}$ , the thickness of the inner leads 516a is 100  $\mu\text{m}$ , and the thickness of the die pad chip attaching part 512a is 40  $\mu\text{m}$ ; then the upper thickness 'D1' should be made equal to 205  $\mu\text{m}$  and the lower thickness 'D2' should be made equal to 275  $\mu\text{m}$ , so that the common distance 'd' is 135  $\mu\text{m}$ .

As shown in Fig. 9, the semiconductor chips 120a, 120b are electrically interconnected to the inner leads 516a via bonding wires 524 using a reverse bonding technology. The reverse bonding wires 524 include balls 550 bonded to the surface of inner leads 516a and stitches 560 bonded to the electrode pads 534 of the semiconductor chips 120.

5 The balls 550 and stitches 560 are formed by a capillary, as used in the conventional wire bonding process. Since there is no ball on the electrode pads 534, no loop is required on the pads. Instead, the wire loop is required on the balls 550 bonded to the inner leads 516a. However, since the inner leads 516a are located more towards the center of package body 526 than the active surfaces 540 of the upper and lower chips 120a, 120b, the wire loop has little  
10 or no effect on the thickness of the package body 526.

It is also preferable to make the bonding wires 530 bonded to the upper semiconductor chip 120a shorter than the bonding wires 532 connected to the lower chip 120b. Bondability of the bonding wires 530 and 532 is proportional to the vertical distance between the chip electrode pads and the leads (because of the margin for the wire loop height), and inversely proportional to the horizontal distance between the chip electrode pads and the leads. By shortening the wires 530 connected to the leads 516a having a smaller vertical distance to the upper chip 120a, bondability is enhanced.

#### The Sixth Embodiment

15 In the stack package structure 600 of Fig. 10, according to a sixth embodiment of the invention, different die pad and lead thicknesses are obtained by partially removing one side of the die pad 612a, as the fifth embodiment. Also similar to the fifth embodiment, the die pad chip attaching part 612a has a thickness of approximately 30-50% of the thickness of the die pad peripheral part 612b and the inner leads 616a, which share the same thickness.

20 Unlike the fifth embodiment, however, the protruding portions of the die pad peripheral part 612b extend downwards giving the cross-section of this embodiment an approximate inverted "U" shape. A vertically balanced structure with reference to the die pad in this embodiment is obtained by down-setting the tie bar. In other words, the die pad is disposed a predetermined distance 'dd' below the tie bar.

25 As an example, a package body 626 has a thickness of 580  $\mu\text{m}$ . The thickness of the upper and lower semiconductor chips 120a, 120b is 120  $\mu\text{m}$ . The thickness of the adhesive 122 is 20  $\mu\text{m}$ . The thickness of the inner leads 616a is 100  $\mu\text{m}$ . And the thickness of the chip attaching part 612a is 40  $\mu\text{m}$ . To make both the distance 'd' from the upper semiconductor chip 120a to the top surface of the package body 626 and the distance 'd' from  
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the lower chip 120b to the bottom surface of the package body 626 equal to 135  $\mu\text{m}$ , the amount of the down-set 'dd' is 25  $\mu\text{m}$ . In this embodiment, upper and lower portions of the package body 626 have the same thickness 'D' with reference to the inner leads 616a and thereby provide a vertically balanced structure with reference to the die pad 612.

In this embodiment, as shown in Fig. 10, the bonding wires 632 connected to the upper chip 120a are preferably made longer than the wires 630 bonded to the lower chip 120b. This is partly because of the difference in chip supporting structures during the first and second wire bonding processes and partly to improve the wire bondability.

#### The Seventh Embodiment

According to a seventh embodiment of this invention, the die pad can be divided into at least two portions. Figs. 11a and 11b provide a plan view and cross-sectional view, respectively of an ultra-thin package device 700 in accordance with this embodiment.

Referring to Figs. 11a and 11b, a die pad 712 is divided into two sub-pads; a first die pad 720 and a second die pad 730. The die pad 712 could be further divided, if necessary. The divided first and second die pads 720, 730 are supported by associated tie bars 740, 750, respectively. Semiconductor chips 120a, 120b are attached to upper and lower surfaces of each of the first and second die pads 720, 730 via adhesive layers 122.

Using the divided die pads 720, 730 of this embodiment, the semiconductor IC chips can be supported while reducing the area occupied by the die pad in the package body 726. As a result, degradation of the reliability of the package device (e.g., delamination or cracking of the package body) can be substantially reduced. This is because the mismatch of Coefficients of Thermal Expansion (CTEs) between the die pad and remaining elements (such as package body 726, semiconductor IC chip 120, and the adhesive layer 122) can be significantly prevented. Alternatively, the ultra-thin package device of the present invention may use a smaller die pad than the IC chip rather than, or in addition to, the plurality of divided die pads to obtain this benefit.

The first and second die pads 720, 730 of the package device 700 in the seventh embodiment of the present invention include chip attaching parts 720a, 730a and peripheral parts 720b, 730b, respectively. The thickness of the chip attaching parts 720a, 730a is about 30-50% of the thickness of leads 716. Also, although Figs. 11a and 11b show identical thicknesses of the die pad peripheral parts 720b, 730b and the chip attaching parts 720a, 730a, it is also possible to make the thickness of the peripheral parts the same as the thickness of the leads, similar to the fourth through sixth embodiments.

### Method for Manufacturing the Ultra-Thin Package

A method for manufacturing ultra-thin package devices according to another aspect of the present invention will now be explained with reference to Figs. 12 and 13. Figs. 12a to 12f are cross-sectional views illustrating the process of partially removing the lead frame die pad. The process shown in these figures is directed toward the package device structure of the fifth and sixth embodiments, wherein the die pad peripheral part protrudes away from the chip attaching part. It should be noted, however, that this process can be modified and revised to form any of the package structures described previously. Other modifications will also be apparent to those skilled in the art.

In this process, a strip of sheet metal for a lead frame, which forms the backbone of the package device is prepared. The lead frame serves as a holding fixture during the assembly process and after forming the package body, it becomes an integral part of the package. Fig. 12a shows a die pad area 802 of the lead frame. The die pad 802 preferably has a thickness of about 100  $\mu\text{m}$ .

Referring to Fig. 12b, photoresists 804, 806 having a thickness of about  $7.0 \pm 1.0 \mu\text{m}$  are deposited on each side of the die pad area 802. Referring to Fig. 12c, masks 810, 812 are aligned above and below the die pad area 802 deposited with the photo-resistors. The masks 810, 812 are then exposed to light 813 to transfer the mask patterns to the lead frame. The masks have predetermined patterns including black patterns 811 for reflecting the light and white patterns for transmitting the light.

The exposed structure is developed and etched to remove the parts of the photoresist that the light did not reach. Chromium (Cr) is then applied to the remaining parts to form the structure shown in Fig. 12d. Referring to Fig. 12d, peripheral photoresist patterns 804a on the upper surface of the die pad area 802 and photoresist patterns 806a on the lower surface of the die pad area 802 are provided. Referring to Fig. 12e, this structure is then etched by spraying an etchant onto the die pad or by dipping the die pad into an etchant solution to partially remove the exposed part from the photoresist patterns 804a, 806a. When partially removing the die pad area 802, the amount of etching depends on factors such as pressure and spraying or dipping time.

Referring next to Fig. 12f, when the photoresist patterns are removed, a die pad structure is obtained that has a chip attaching part 820 that is thinner than the peripheral part 830 is obtained. Since the other parts of the lead frame, including inner leads, outer leads, and tie bars, are not etched, they have the same thickness as the die pad peripheral part 830.

Figs. 13a to 13i are cross-sectional views illustrating the process for packaging an ultra-thin semiconductor chip onto a lead frame produced by the process explained above with reference to Figs. 12a to 12f. Referring to Fig. 13a, a wafer 902 is prepared by a semiconductor fabrication process. The wafer 902 has a plurality of IC devices. A UV adhesive tape 904 is adhered to the active surface 903 of the wafer 902. The UV tape 904 has near zero adhesion following UV irradiation, thereby permitting virtually no stress tape removal without adhesive residue. The UV tape 904 attached to the active surface 903 of the wafer 902 also has excellent shock and vibration absorption to protect the wafer 902 against breakage and damage during a pre-process such as back-grinding. An adhesive UV tape 906 that loses adhesiveness after UV irradiation is indirectly attached to the back surface (opposite the active surface) of the wafer 902 after grinding via an additional adhesive layer 908. The adhesive layer 908 is preferably a film type adhesive made of an epoxy resin, and includes a hardener (e.g., amine) and a coupling agent (e.g., silane).

Referring to Fig. 13a, a first UV irradiation step can be performed on the active surface 903 of the wafer 902 using a UV lamp. The adhesive tape 904 attached to the active surface 903 thereby loses its adhesiveness and can be removed with no adhesive residue and without damaging the wafer 902. This first UV irradiation step is optional. As shown in Fig. 13b, a second UV irradiation step is performed on the backside of the wafer 902. The adhesive UV tape 906 thereby loses its adhesiveness to the adhesive layer 908 and can then be easily removed from the layer 908.

At this point, as shown in Fig. 13c, the wafer is cut and separated into individual chips 910 during a wafer sawing step by scribing the wafer 902 using a cutting means 912 such as a diamond wheel. Since the adhesive layer 908 and the adhesive UV tape 906 are attached to the back side of each chip 910, each of the chips 910 maintains the general cross-sectional structure of the wafer 902 when separated.

Referring Fig. 13d, the individual chips 910 are completely separated from the wafer using a vacuum pickup means 920 (die pickup step). Because the UV tape 906 loses its adhesiveness to the adhesive layer 908, the individual chips 910 can be easily separated from the tape 906. The adhesive layer 908, however, remains attached to the back side of the separated chips 910.

Referring Fig. 13e, in the first die bonding step, each chip 910 is attached to a die pad 932 of a lead frame 930 produced according to the process of Figs. 12a through 12f. The lead frame 930 includes the die pad 932 and leads 938. The die pad 932 includes a chip attaching part 934 and a peripheral part 936. The peripheral part 936 protrudes from the chip attaching

part 934 and has the same thickness as the leads 938. The thickness of the chip attaching part 934 preferably ranges between about 30-50% of the thickness of the peripheral part 936.

The chip bonded to the top surface of the chip attaching part 934 is called an upper chip 910a. In this case, the top surface of the chip attaching part 934 is the side located in the direction of protrusion of the peripheral part 936. Since the adhesive layer 908 remains on the back side of the upper chips 910a, there is no need to perform an additional adhesive applying step before die bonding the upper chip 910a.

Next, as shown in Fig. 13f, a second die bonding step is performed in which a lower chip 910b is attached to the bottom surface of the chip attaching part 934. Since the lower chip 910b also has an adhesive layer 908 on its back side, the second die bonding step can also be accomplished without an additional adhesive applying step. In the first and second die bonding processes, the order of bonding of the upper and lower chips is not significant.

Referring to Fig. 13g, the lead frame 902 is aligned and fixed onto the supporter 940a and the upper chip 910a. The lead frame leads 938 are electrically interconnected by bonding wires 942 in a first wire bonding step. As shown in Fig. 13h, the lead frame 902 is aligned and fixed onto the supporter 940b and the lower chip 910b. The lead frame leads 938 are electrically interconnected by bonding wires 945 in a second wire bonding step. The order of the wire bonding steps is not significant. However, considering the bondability of wires 942 and 945, it is preferable to shorten wires 942 connected to the chips disposed in the direction of the protrusion of the peripheral part 936, in this case upper chip 910a. This is because the vertical distance from the active surface of the upper chip 910a to the peripheral part 936 is smaller than that of the lower chip 910b. The first and second wire bonding steps are preferably performed using a reverse wire bonding technology where a capillary forms balls on the lead frame leads 938 and stitches on the chip electrode pads.

Referring to Fig. 13i, following the second wire bonding step, the package body 950 is molded using an injection molding process. The lead parts 938, extending outside of the package body 950, are bent and formed in a proper shape to complete the ultra-thin package device.

Because the package device according to the present invention has very small thickness, the curing speed of the package body is higher. It is preferable, therefore to perform the molding step at a low temperature. The formation of the package body is preferably performed in a temperature environment ranging between about 170-175°C.



## Applications

The ultra-thin package devices of the present invention can be used in various portable electronic appliances including digital cameras, MP3 players, Handheld Personal Computers (HPCs), Personal Digital Assistants (PDAs), mobile phones, and other devices.

Figs. 14a and 14b, for example, show a memory card into which an ultra-thin package device of the present invention is integrated. Fig. 14a is a plan view of the memory card and Fig. 14b is a cross-sectional view taken along the line 14b-14b of Fig. 14a.

Generally, memory cards are produced using flash memories. Several companies presently manufacture memory cards. For example, SmartMedia memory cards by Toshiba, MemoryStick cards by Sony, CompactFlash cards by Sandisk, MultiMedia Cards by Gimens and Sandisk, and SD (Secure Digital) cards are all available. The embodiment shown in Figs. 14a and 14b shows the implementation of this invention in a MemoryStick memory card.

Referring to Figs. 14a and 14b, a memory card 960 includes a main board 967. Terminal pads 961, a controller mounting area 962, a mounting area for passive elements 963, and a memory mounting area 966 are formed on the main board 967. The memory mounting area 966 is defined by and separated from other areas by an interposer 965. The dimensions of the MemoryStick Duo card 960 are 31.0 mm of length (L), 20.0 mm of width (W), and 1.6 mm of height. The memory mounting area 966 has a length (L1) of 12 mm and a width (W1) of 18 mm. As shown in Fig. 14b, the height (H) of the interposer 965 is about 0.7 mm. Since the package device 1000 of the present invention has a thickness of less than 0.58 mm, the package device can be accommodated within the memory mounting area 966 of the memory card 960 without exceeding the maximum height of 0.7 mm of the interposer 965 even when the outer leads of the package device are accounted for. Accordingly, the capacity of the memory card can be at least doubled while still permitting the miniaturization of the memory card.

The thin package technology of the present invention can also be applied to a package device using a single semiconductor IC chip. Examples of this aspect of the invention are shown in Figs. 15 and 16. Referring to Fig. 15, a package device 550 includes a single semiconductor IC chip 120. A chip attaching part 572a of a die pad 572, to which the chip 120 is attached, is thinner than a die pad peripheral part 572b. The thickness of the chip attaching part 572a is preferably between about 30-50% of the thickness of the peripheral part 572b. Leads 516 have the same thickness as the peripheral part 572b. The peripheral part 572b protrudes upwards towards the chip 120 from the chip attaching part 572a, and the die pad is down set to achieve a balanced structure with reference to the leads 516.

For example, when the thickness of the chip 120 is 120  $\mu\text{m}$ , the thickness of an adhesive layer 122 is 20  $\mu\text{m}$ , and the thickness of the leads 516 is 100  $\mu\text{m}$ , then the thickness of the chip attaching part 572a should be about 40  $\mu\text{m}$ . The upper and lower portions of the package body 580 have an equal thickness of about 185  $\mu\text{m}$ . In this example, the overall thickness of the package device 550 is 470  $\mu\text{m}$ , and the amount of down set of the die pad is 40  $\mu\text{m}$ .

Referring now to Fig. 16, when a peripheral part 672b of a die pad 672 protrudes downwards from a chip attaching part 672a, opposite the chip 120, a package body 670 is formed by aligning a top surface of the die pad 672 to the top surfaces of leads 670 and performing an unbalanced molding with reference to the leads 670. In this embodiment, a semiconductor chip 120 is attached to the top surface of the die pad 672 via an adhesive layer 122. For instance, when the thickness of the chip 120 is 120  $\mu\text{m}$ , the thickness of the adhesive layer 122 is 20  $\mu\text{m}$ , the thickness of the leads is 100  $\mu\text{m}$ , and the thickness of the chip attaching part 672a is 40  $\mu\text{m}$ , the upper part of the package body 686 has a thickness of 285  $\mu\text{m}$ , while the thickness of the lower part of the package body 686 is 85  $\mu\text{m}$ . It should be noted, however, that the distance from the active surface of the chip 120 to the top surface of the package body 686 is identical to the distance from the back surface of the chip 120 to the bottom surface of the package body 686, thereby providing a vertically balanced structure. According to various aspects of the present invention, it is therefore possible to provide an ultra-thin package device having a thickness of equal to or less than 0.5 mm.

Although various preferred embodiments of this invention have been disclosed and described in the drawings and specification, these embodiments are provided by way of example, and not of limitation. Various modifications to these embodiments, in both arrangement and detail, will be apparent to those skilled in the art. The invention should therefore be interpreted to cover all such modifications coming within the spirit or scope of the following claims.